Molarity Problems

1. Sea water contains roughly 28.0 g of NaCl per liter. What is the molarity of sodium chloride in sea water?

$$\frac{28.0\text{ g NaCl}}{1\text{ L}}\left(\frac{1\text{ mol}}{58.44\text{ g}}\right) = 0.479\text{ M}$$

2. What is the molarity of 5.30 g of Na_2CO_3 dissolved in 400.0 mL solution?

$$5.30\text{ g } Na_2CO_3\left(\frac{1\text{ mol}}{105.99\text{ g}}\right)\left(\frac{1}{0.4\text{ L}}\right) = 0.125\text{ M}$$

3. How many moles of Na_2CO_3 are there in 10.0 L of 2.0 M solution?

$$\frac{2.0\text{ mol}}{1\text{ L}} \times 10.0\text{ L} = 20.\text{ moles}$$

4. How many moles of NaCl are contained in 100.0 mL of a 0.20 M solution?

$$\frac{0.20\text{ mol}}{1\text{ L}}\left(\frac{0.1000\text{ L}}{1}\right) = 0.02\text{ mole}$$

5. What weight (in grams) of NaCl would be contained in problem 4?

$$0.02\text{ mole}\left(\frac{58.44\text{ g}}{1\text{ mol}}\right) = 1.2\text{ g}$$

6. What weight (in grams) of H_2SO_4 would be needed to make 750.0 mL of 2.00 M solution?

$$\frac{2.00\text{ mol}}{1\text{ L}}\left(\frac{0.7500\text{ L}}{1}\right)\left(\frac{98.08\text{ g}}{1\text{ mol}}\right) = 147\text{ g}$$

7. What volume (in mL) of 18.0 M H_2SO_4 is needed to contain 2.45 g H_2SO_4?

$$2.45\text{ g}\left(\frac{1\text{ mol}}{98.08\text{ g}}\right)\left(\frac{\text{L}}{18\text{ mol}}\right)\left(\frac{1000\text{ mL}}{1\text{ L}}\right) = 1.39\text{ mL}$$

8. What volume (in mL) of 12.0 M HCl is needed to contain 3.00 moles of HCl?

$$3.00\text{ mol}\left(\frac{1\text{ L}}{12.0\text{ mol}}\right)\left(\frac{1000\text{ mL}}{1\text{ L}}\right) = 250\text{ mL}$$

9. What is the molarity of a solution made by dissolving 20.0 g of H_3PO_4 in 50.0 mL of solution?

$$20.0\text{ g}\left(\frac{1\text{ mol}}{98\text{ g}}\right)\left(\frac{1}{0.050\text{ L}}\right) = 4.08\text{ M}$$

10. Determine the number of moles of solute to prepare these solutions:

a) 2.35 liters of a 2.00 M $Cu(NO_3)_2$ solution.

$$\frac{2.00\text{ mol}}{1\text{ L}}\left(\frac{2.35\text{ L}}{1}\right) = 4.70\text{ mol}$$

b) 3.00 L of a 0.500 M $MgCO_3$ solution.

$$\frac{0.500\text{ mol}}{1\text{ L}}\left(\frac{3.00\text{ L}}{1}\right) = 1.50\text{ mol}$$

11. Determine the grams of solute to prepare these solutions:

a) 0.289 liters of a 0.00300 M $Cu(NO_3)_2$ solution.

$$\frac{0.00300\text{mol}}{1\text{L}}\left(\frac{0.289\text{L}}{1}\right)\left(\frac{187.57\text{g}}{1\text{mol}}\right) = \boxed{0.163\text{g}}$$

b) 4.35 L of a 3.50 M $CaCl_2$ solution.

$$\frac{3.50\text{mol}}{1\text{L}}\left(\frac{4.35\text{L}}{1}\right)\left(\frac{110.98}{1\text{mol}}\right) = \boxed{1690\text{g}}$$

12. Determine the final volume of these solutions:

a) 4.67 moles of Li_2SO_3 dissolved to make a 3.89 M solution.

$$4.67\text{mol}\left(\frac{1\text{L}}{3.89\text{mol}}\right) = \boxed{1.17\text{L}}$$

b) 4.907 moles of Al_2O_3 to make a 0.500 M solution.

$$4.907\text{mol}\left(\frac{1\text{L}}{0.500\text{mol}}\right) = \boxed{9.81\text{L}}$$

c) 0.783 grams of Na_2CO_3 to make a 0.348 M solution.

$$0.783\text{g}\left(\frac{1\text{mol}}{105.99\text{g}}\right)\left(\frac{1\text{L}}{0.348\text{mol}}\right) = \boxed{0.0212\text{L}}$$

Percent solutions

1. What is the percent-by-mass, %(m/m), concentration of sucrose in a solution made by dissolving 7.6 g of sucrose in 83.4 g of water?

$$\frac{7.6}{7.6+83.4}\times 100 = \frac{7.6}{91.0}\times 100 = \boxed{8.4\%}$$

2. How many grams of sulfuric acid is in 25.0 g of 8.00 % sulfuric acid solution?

$$\frac{\text{mass of solute}}{\text{mass of solution}}\times 100 = \%$$

$$\frac{\%\,(\text{mass of solution})}{100} = \text{mass of solute} \qquad \frac{(8.00)(25.00)}{100} = \boxed{2\text{g}}$$

3. Calculate the volume percent, %(v/v), of solute in the following solution: 20.0 mL of methyl alcohol in enough water to give 475 mL of solution.

$$\frac{20.0\text{mL}}{475\text{mL}}\times 100 = \boxed{4.21\%}$$

4. What volume of ethanol is in 55.0 mL of a 10% solution of ethanol?

$$\frac{\text{volume of solute}}{\text{volume of solution}}\times 100 = \%$$

$$\text{volume of solute} = \frac{(\%)(\text{volume of solution})}{100} = \boxed{5.5\text{ mL}}$$

Dilutions

1. A stock solution of 1.00 M NaCl is available. How many milliliters are needed to make 100.0 mL of 0.750 M? $M_1V_1 = M_2V_2$ $V_1 = \frac{M_2V_2}{M_1}$ $\left(\frac{0.75\,mol}{L}\right)\left(\frac{0.1\,L}{1}\right)\left(\frac{1\,L}{1\,mol}\right) = 0.075\,L$ ⇓ 75 mL

5. What volume of 0.250 M KCl is needed to make 100.0 mL of 0.100 M solution?
Same as #1 $\left(\frac{0.1\,mol}{1L}\right)\left(\frac{0.100\,L}{1}\right)\left(\frac{1\,L}{0.250\,mol}\right) = 0.04\,L \rightarrow$ 40 mL

6. Concentrated H_2SO_4 is 18.0 M. What volume is needed to make 2.00 L of 1.00 M solution?
Same as #5 $\left(\frac{1.00\,mol}{L}\right)\left(\frac{2.00\,L}{1}\right)\left(\frac{1\,L}{18\,mol}\right) = 0.111\,L$

7. Concentrated HCl is 12.0 M. What volume is needed to make 2.00 L of 1.00 M solution?
Same as #6 $\left(\frac{1.00\,mol}{1L}\right)\left(\frac{2.00\,L}{1}\right)\left(\frac{1\,L}{12.0\,mol}\right) = 0.167\,L$

8. A 0.500 M solution is to be diluted to 500.0 mL of a 0.150 M solution. How many mL of the 0.500 M solution are required?
Same as #7 $\left(\frac{0.150\,mol}{1L}\right)\left(\frac{0.500\,L}{1}\right)\left(\frac{1\,L}{0.500\,mol}\right) = 0.150\,L$

9. A stock solution of 10.0 M NaOH is prepared. From this solution, you need to make 250.0 mL of 0.375 M solution. How many mL will be required?
Same as #8 $\frac{0.375\,mol}{1L}\left(\frac{0.250\,L}{1}\right)\left(\frac{1\,L}{10\,mol}\right) = 0.00938\,L$

10. 2.00 L of 0.800 M $NaNO_3$ must be prepared from a solution known to be 1.50 M in concentration. How many mL are required?
Same as #9 $\frac{0.800\,mol}{1L}\left(\frac{2.00\,L}{1}\right)\left(\frac{1\,L}{1.50\,mol}\right) = 1.07\,L$

8. Calculate the final concentration if 2.00 L of 3.00 M NaCl and 4.00 L of 1.50 M NaCl are mixed. Assume there is no volume contraction upon mixing.

$$\frac{\text{moles Solution \#1} + \text{moles Solution \#2}}{\text{total volume}} = \text{final concentration}$$

$$\frac{\frac{3.00\,mol}{L}\left(\frac{2.00\,L}{1}\right) + \frac{1.50\,mol}{1L}\left(\frac{4.00\,L}{1}\right)}{6.00\,L} = \frac{12\,mol}{6\,L} = 2.00\,M$$

pH—pOH—$[H^+]$—$[OH^-]$

1. Calculate the values of both pH and pOH of the following solutions (assume complete ionization):

	pH	pOH
a. 0.020 M HCl = 2.0×10^{-2} H^+	1.7	12.3
b. 0.0050 M NaOH 5.0×10^{-3} $[OH^-]$	2.3	11.7
c. 7.2×10^{-8} M H_2SO_4 $\times 2$ $[H^+]$	6.8	7.2
d. 0.00035 M $Ca(OH)_2$ 3.5×10^{-4} $\times 2$ $[OH^-]$	3.2	10.8

$[H^+]$	$[OH^-]$	pH	pOH	ACID BASE NEUTRAL
1×10^{-3}	1×10^{-11}	3	11	Acid
1×10^{-8}	1×10^{-6}	8	6	Base
1×10^{-9}	1×10^{-5}	9	5	Base
1×10^{-2}	1×10^{-12}	2	12	Acid
1×10^{-7}	1×10^{-7}	7	7	NEUTRAL
3.16×10^{-5}	3.16×10^{-10}	4.5	9.5	Acid
2.0×10^{-5}	5.0×10^{-10}	4.7	9.3	Acid
5.0×10^{-12}	2.0×10^{-3}	11.3	2.7	Base
5.0×10^{-11}	2.0×10^{-4}	10.3	3.7	Base

A = acid
B = base.

Titrations

1. What is the molarity of a NaOH solution if 25.00 mL is required to neutralize 40.00 mL of a 1.50 *M* solution of H_2SO_4? $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

$$\frac{1.50\ mol_A}{1\ L}\left(\frac{0.040\ L_A}{1}\right)\left(\frac{2\ mol_B}{1\ mol_A}\right)\left(\frac{1}{0.025\ L}\right) = 0.48\ M$$

2. Calculate the mL of a 0.600 *M* solution of HNO_3 necessary to neutralize 28.55 mL of a 0.450 *M* solution of KOH. $HNO_3 + KOH \rightarrow KNO_3 + H_2O$ (HNO_3: 0.600M)

$$\frac{0.450\ mol_B}{1\ L}\left(\frac{0.02855\ L}{1}\right)\left(\frac{1\ mol_A}{1\ mol_B}\right)\left(\frac{L}{0.600\ mol}\right)\left(\frac{1000\ mL}{1\ L}\right) = 9.64\ mL$$

3. How many grams of $Ca(OH)_{2\,(s)}$ are required to neutralize 52.68 mL of a 0.750 *M* $H_2SO_{4\,(aq)}$ solution ? $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

$$\frac{0.750\ mol}{L}\left(\frac{0.05260\ L}{1}\right)\left(\frac{1\ mol\ Ca(OH)_2}{1\ mol\ H_2SO_4}\right)\left(\frac{74.1\ g}{1\ mol\ Ca(OH)_2}\right) = 2.93\ g$$

4. How many mL of 0.500 *M* NaOH are necessary to neutralize 20.0 mL of each of the following acids?

A. 0.150 *M* HNO_3 B. 0.250 *M* H_2SO_4 C. 0.450 *M* H_3PO_4

20 mL 20 mL 20 mL

0.006 L 0.02 L 0.054 L

or or

6 mL 20 mL 54 mL

$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$ $\frac{0.150\ mol}{1\ L}\left(\frac{0.020\ L}{1}\right)\left(\frac{1}{1}\right)\left(\frac{1\ L}{0.5\ mol}\right)$

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ $\frac{0.250\ mol}{1\ L}\left(\frac{0.020\ L}{1}\right)\left(\frac{2}{1}\right)\left(\frac{1\ L}{0.5\ mol}\right)$

$3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$ $0.450\ M\ (0.020)\left(\frac{3}{1}\right)\left(\frac{1\ L}{0.5\ mol}\right)$